DOCUMENT RESUME

ED 086 551 SE 017 223

AUTHOR Negus, LeRoy
TITLE Let's Use the Metric System: A Supplement to Mathematics K-6.
INSTITUTION New York State Education Dept., Albany. Bureau of Elementary Curriculum Development.
PUB DATE 73
NOTE 15p.

EDRS PRICE MF-$0.65 HC-$3.29
DESCRIPTORS *Curriculum; *Elementary School Mathematics; Guides; Instruction; Instructional Materials; Learning Activities; *Measurement; *Metric System; Objectives; *Teaching Techniques

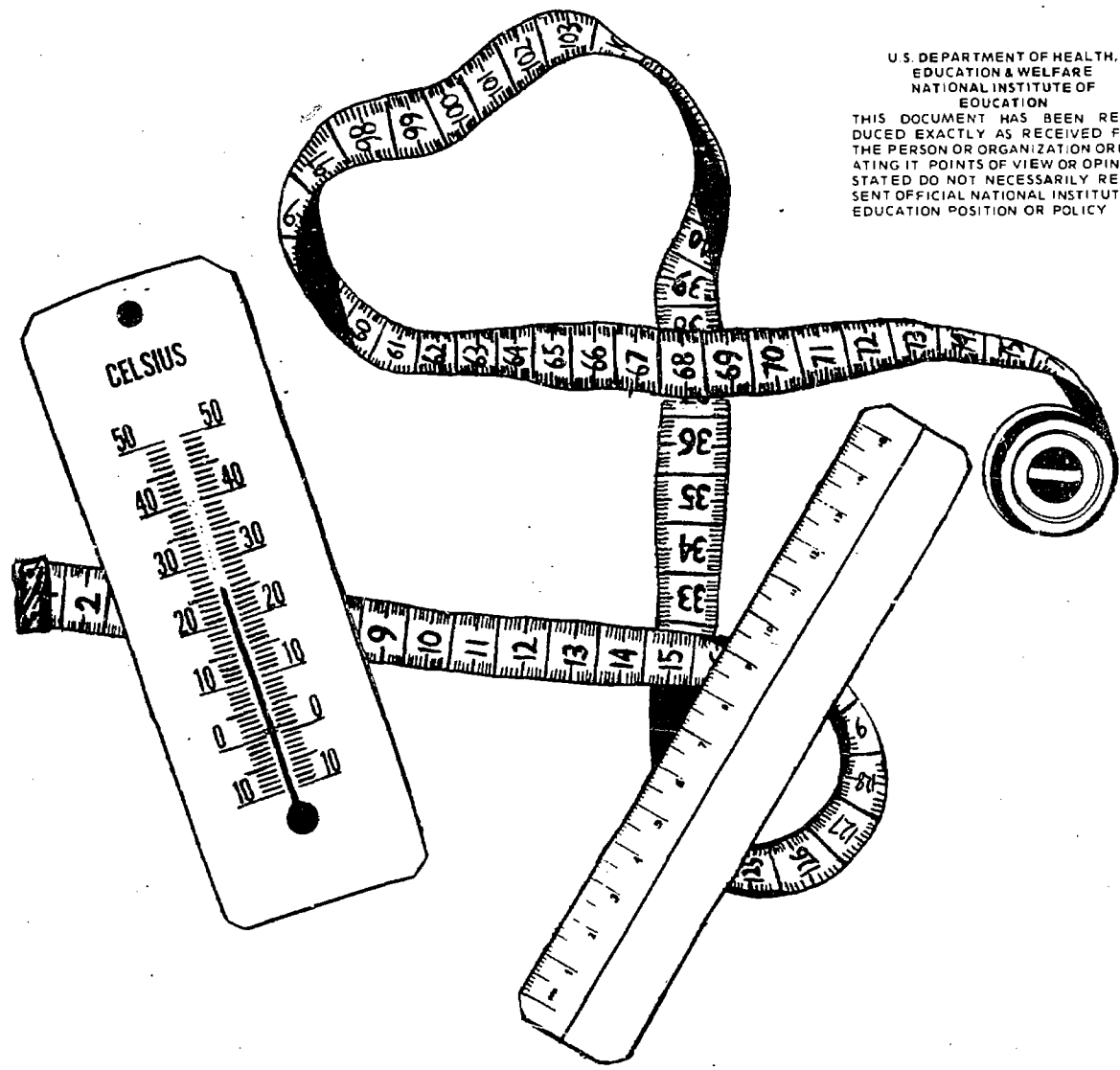
ABSTRACT

This bulletin provides elementary school teachers with some information about the metric system and some suggestions for teaching it. A history of the development of the system is given followed by a grade by grade guide to objectives and activities to be used with lessons on measurement with the metric system. The activities stress the decimal character of the metric system and provide opportunities for the students to gain an intuitive feeling for the comparative size of the various units of measure. (JP)

SE

LET'S USE THE METRIC SYSTEM

a supplement to Mathematics K-6



The University of the State of New York
THE STATE EDUCATION DEPARTMENT
Bureau of Elementary Curriculum Development
Albany, New York 12224

THE UNIVERSITY OF THE STATE OF NEW YORK

Regents of the University (with years when terms expire)

1984	Joseph W. McGovern, A.B., J.D., L.H.D., LL.D., D.C.L. Chancellor	New York
1985	Everett J. Penny, B.C.S., D.C.S., Vice Chancellor	White Plains
1978	Alexander J. Allan, Jr., LL.D., Litt.D.	Troy
1987	Carl H. Pforzheimer, Jr., A.B., M.B.A., D.C.S., H.H.D.	Purchase
1975	Edward M.M. Warburg, B.S., L.H.D.	New York
1977	Joseph T. King, LL.B.	Queens
1974	Joseph C. Indelicato, M.D.	Brooklyn
1976	Mrs. Helen B. Power, A.B., Litt.D., L.H.D., LL.D.	Rochester
1979	Francis W. McGinley, B.S., J.D., LL.D.	Glens Falls
1986	Kenneth B. Clark, A.B., M.S., Ph.D., LL.D., L.H.D., D.Sc.	Hastings on Hudson
1983	Harold E. Newcomb, B.A.	Owego
1981	Theodore M. Black, A.B., Litt. D.	Sands Point
1988	Willard A. Genrich, LL.B., L.H.D.	Buffalo
1982	Emlyn I. Griffith, A.B., J.D.	Rome

President of the University and Commissioner of Education
Ewald B. Nyquist

Executive Deputy Commissioner of Education
Gordon M. Ambach

Deputy Commissioner for Elementary, Secondary, and Continuing Education
Thomas D. Sheldon

Associate Commissioner for Instructional Services
William L. Bitner III

Assistant Commissioner for Instructional Services (General Education)
Bernard F. Haake

Director, Division of General Education
Ted T. Grenda

Chief, Bureau of Mathematics Education
Frank S. Hawthorne

Director, Division of Curriculum Development
Gordon E. Van Hooft

Chief, Bureau of Elementary Curriculum Development
Robert H. Johnstone

FOREWORD

The United States Metric Study of 1968 - 71 recommended, "That the United States change to the International Metric System deliberately and carefully." On August 18, 1972 the United States Senate unanimously passed the Metric Conversion Act which calls for the gradual conversion to the metric system over a 10 year period. The House of Representatives has not acted on the Metric Conversion Act at this time.

The metric system is a logical system of measurement with most of the measurement standards based on natural phenomena. The conversion factors within the system are powers of 10. The metric system is now used by over 90% of the nations of the world. In 1965 the British announced their move to metrics. In 1970 Australia and Canada announced that they would change to the metric system. In a world moving more and more toward the metric system, the United States must use metrics in scientific work and trade in order to collaborate with other nations.

The metric system is not new to our schools. It has been a minor part of every student's education. However, with the increased use of the metric system almost a certainty, our schools must provide further instruction in the metric measurement system. The instruction in the metric system should not, however, progress much beyond the common metric units used in everyday life as they are introduced into society. Instruction in the metric system should not lead to mental gymnastics with a great deal of memorizing and conversion between the English and metric measurement systems.

The bulletin has been prepared to provide elementary school teachers with some information about the metric system and some suggestions for teaching it. The bulletin should be used as a supplement to the Department's syllabus, Mathematics K - 6 and information pamphlet No. 5, Geometry and Measurement. The usual experiences given children for developing measurement facility should still be a part of the educational program. Such activities as measuring the length of a desk in "pencils" and the width of a book in "macaronis" are worthwhile in developing a measurement sense.

For a period of time both the metric and English systems of measurement will be used. Both systems should be taught in this transition period. However, conversion from one system to the other should be treated casually and quite informally. Pupils should develop a feeling for comparison between units - a meter is a little longer than a yard and a liter is a little larger than a quart.

This publication was prepared by LeRoy Negus, Associate in Mathematics Education, from material assembled by Miss Toby Axler of Russell Sage College, who interned with the Bureau of Mathematics Education, New York State Education Department.

Robert H. Johnstone, Chief
Bureau of Elementary
Curriculum Development

Gordon E. Van Hooft, Director
Division of Curriculum Development

HISTORY

The metric system was developed in France in the latter part of the 18th century when the National Assembly of France, on May 8, 1790 was called upon to create an invariable standard for weights and measures. The French Academy developed a decimal-based system in which the standard unit of length was the metre (which we spell meter), derived from the Greek word metron, meaning "a measure." The meter was to be equal to one ten-millionth of the distance from the north pole to the equator measured along a meridian of the earth near Dunkirk and Barcelona. This system was based on a proposal that Gabriel Mouton made in 1670.

The metric unit of mass, called the "gram," was defined as the mass of one cubic centimeter of water at its maximum density. The unit of fluid capacity, called the "liter," was defined as a cubic decimeter or one thousand cubic centimeters.

As time passed, revisions were made in the metric system and the number of countries adopting it increased. In 1866 the United States Congress made it lawful to use the metric system of weights and measures in any and all business. In 1893 the Secretary of the Treasury of the United States declared that metric standards would be the fundamental weights and measures standards of the United States. Thus, the yard was, and is, legally defined as a fractional part of a meter and the pound as a fractional part of a kilogram, a fact unknown by many.

The Soviet Union's launch of Sputnik in 1957 renewed interest in science and mathematics, and, in 1959, the yard was defined as exactly 0.9144 meter and the avoirdupois pound as 0.45359237 kilogram. In 1960 the meter was defined as 1,650,763.73 wave lengths in vacuum of the orange-red line of the spectrum of Krypton 86. This standard is accurate to 1 part in 100,000,000 and has the advantage of being reproducible in scientific laboratories throughout the world.

THE METRIC SYSTEM

The metric system is a decimal-based system and somewhat parallels the decimal numeration system as shown in the chart

Decimal Numeration		Metric	
thousands		kilo	
hundreds		hecto	
tens		deka	
ones			
.		.	
tenths		deci	
hundredths		centi	
thousandths		milli	

Prefixes assigned to the base units designate powers of 10. Greek derived prefixes are assigned to the multiples and Latin prefixes are assigned to the submultiples.

	Prefix	Length	Volume	Mass
10 x 10 x 10 = 1000	kilo	kilometer (km)	kiloliter	kilogram
10 x 10 = 100	hecto	hectometer (hm)	hectoliter	hectogram
10	deka	dekameter (dam)	dekaliter	dekagram
base unit		meter (m)	liter	gram
1/10	deci	decimeter (dm)	deciliter	decigram
1/10 x 1/10 = 1/100	centi	centimeter (cm)	centiliter	centigram
1/10 x 1/10 x 1/10 = 1/1000	milli	millimeter (mm)	milliliter	milligram

Only the prefixes - milli, centi, deci, and kilo should be stressed in the elementary grades.

The units are interrelated - under standard conditions, one cubic centimeter of water is one milliliter and has a mass of one gram.

In the elementary school the distinction between mass and weight can be mentioned but children should be allowed to use the term "weight" in their work. Mass is a fundamental concept. Like length and time it is one of the basic ideas upon which much else is defined. Mass is sometimes thought of as the amount of material in an object. Weight is the measure of gravitational force on a mass (object) and varies with the location of the object. The weight of an astronaut on the moon is less than his weight on the earth because the force of gravity is less on the moon. He may even be weightless in a space station such as Skylab. However, his mass is the same in all three places. We have been so used to using the term "weight" incorrectly that "weight" will still probably be used for everyday purchases even in cases where the correct term would be "mass."

SUGGESTED ACTIVITIES

TEACHING AIDS

Aids useful for teaching the metric system should be available. Meter sticks and 20-or 30-centimeter rulers graduated only in metric units are desirable. Pan balances with gram weights are useful for studying about mass and containers graduated in metric units are useful for studying volume. Heavy cardboard is helpful in making metric rulers and models of square decimeters, square meters, cubic decimeters, cubic meters, and the like. Many of the colored rods, for example Cusinaire rods, have unit blocks that are cubic centimeters. A Celsius (commonly called centigrade) thermometer should also be available.

Schools having science programs which employ metric measures may find it helpful to coordinate mathematics with science.

KINDERGARTEN

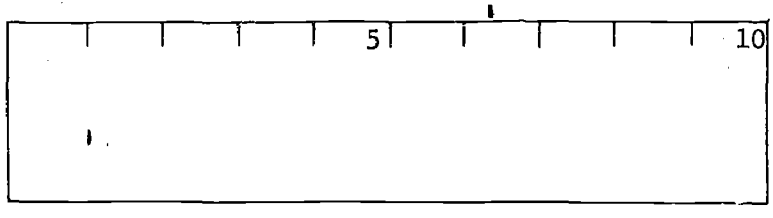
Length, mass, capacity, time, and temperature are the most important variables that can be learned by young children. Introduce metric units of measure such as meter, gram, and liter, in a very informal manner. Offer children the opportunity to use metric units in play activities using sand and water. If a child comes in with a new toy, consider the quantitative aspects of it. Find its length, height, weight, and the distance around various parts of the toy.

Practically everything in the classroom may be compared by height, weight, or length. Try to give some point to the activities. For example, how high should the water fountain be? Of course, memorization and exercises calling for conversion from one system of measurement to another are out of place in the primary grades.

GRADE 1

Children need not learn the conversion factors for many years, but they should have a variety of measuring activities using metric units.

Explore counting on a metric ruler.



Have a child measure, with his metric ruler, various objects in the room - his desk, pencil, book, a floor tile.

Comparison should be used to develop an understanding of the basic units. Is a meter about the length of the school building, or about the length of a paper clip, or about the distance that a first grader can reach between his outstretched arms. Is a liter about the equivalent of a quart, or would it fill a bathtub or a swimming pool?

Liter containers should be available along with cups and quarts for comparison.

The pupils can read and record the temperature each day from both a Celsius and a Fahrenheit thermometer.

Graphs are useful tools in working with units of measure. First graders can make and interpret simple charts and graphs. Graphs can be made from daily temperature readings. Or have the children measure the lengths of classroom objects (measurements of the body such as heights or arm lengths can also be used) and write their measurements on a chart on the chalkboard. An exciting comparison to be charted on a graph is the shadow lengths of pupils at different times of the day or year. Any drawing, picture, or diagram should be considered a "graph." Children should not be forced into a particular format, say "bar graph."

GRADE 2

Begin developing relationships between the prefixes, stressing the "tenness" of the system and comparing it to the base 10 numeration system. Reinforce this relationship with appropriate activities. As an example, have the pupil take colored water or sand from a large container and count the number of times he must fill a deciliter graduated cylinder in order to fill a liter container. This will show the child that 10 deciliters is the equivalent of 1 liter.

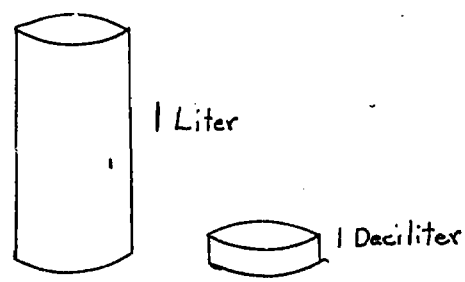
Have the children make meter tapes and measure and label distances around the room. Encourage the pupils to learn the more common prefixes - milli, centi, deci, and kilo.

Introduce the symbols for metric units: mm for millimeter
cm for centimeter
m for meter
km for kilometer

(Note that no periods are used in the abbreviations)

Appropriateness of measuring units should be discussed. To illustrate, the width of a book would be measured in centimeters, the length of a room in meters, and the distance between two cities in kilometers. Speed limits will be given in km per hour.

Likewise, compare milliliter and liter. Have the pupil cite situations that might require a unit of measurement smaller than the milliliter or larger than the liter.



GRADE 3

Practice using and reading the metric ruler to develop measurement skills. Most children find the decimal notation easier to comprehend when they use instruments whose marks they can see. Thus, metric rulers or pan balances are helpful. The fixed points on the Celsius scale (centigrade thermometer) are 0°, the temperature of freezing water, and 100°, the temperature of boiling water at standard sea level pressure.

Learn the relations:

10	millimeters	= 1	centimeter
100	millimeters	= 1	decimeter
1000	millimeters	= 1	meter
10	centimeters	= 1	decimeter
100	centimeters	= 1	meter
1000	meters	= 1	kilometer

Conversion within the metric system is fairly easy. For example, how many centimeters in 28 kilometers?

Answer: 28 x 1000 x 100 cm = 2,800,000 cm

Compare with the English system. How many inches in 28 miles?

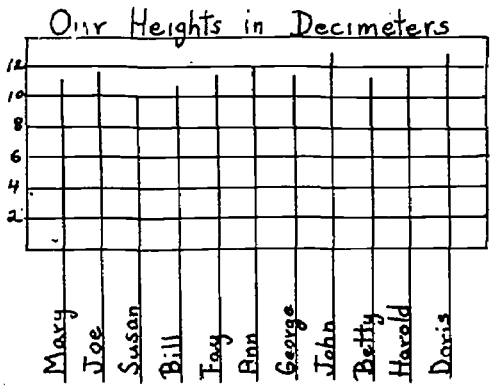
Answer: 28 x 5280 x 12 = 1,774,080 inches

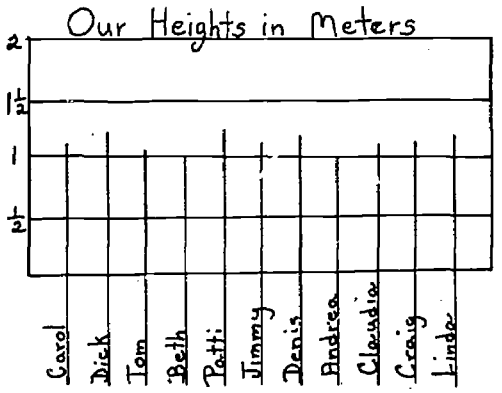
Introduce addition and subtraction with common measures. Example, add: 4 meters, 3 decimeters, 2 centimeters to 2 meters, 3 decimeters, 1 centimeter. Put the answer in terms of centimeters.

Provide plenty of practice for using and reading linear, volume, weight (mass) and temperature metric measures.

Again, graphs can be introduced and used profitably.

Constantly seek interesting examples of metric measures used in the world around us. Track and field games, Olympic contests, and news reports from other countries offer good examples of relevant things that might be discussed with children.





GRADE 4

Continue metric measurement activities.

Learn the relations: 1 millimeter = 1/10 centimeter = 1/1000 meter
1 centimeter = 1/100 meter
1 meter = 1/1000 kilometer

Continue addition and subtraction with common measures.

Examples with regrouping:

6 dm	4 cm	5 mm	compare with:	645
+2 dm	7 cm	7 mm		+277

6 dm	4 cm	5 mm	compare with:	645
-2 dm	7 cm	7 mm		-277

Weights (masses) of 0.5 kg, 1 kg, and 5 kg should be provided, or made, so that pupils may learn to form their own estimations. A #303 can of vegetables is about 0.5 kg. A quart of milk with the carton is about 1 kg. An ordinary building brick has a mass of approximately 2 kg. A gallon of maple syrup or oil base paint is approximately 5 kg. For smaller measurements, an ordinary paper clip has a mass of about 1 gram and a nickel about 5 grams.

Encourage the children to find the mass of a textbook, a paperback, or a large dictionary.

Plot the growth (length or weight) of a young mouse or hamster. Pupils should become familar with the number of millimeters in everyday containers such as soda bottles and milk cartons. Estimation should be a part of every measurement problem.

Continue use of Celsius thermometer.

GRADE 5

Continue with a variety of metric measurement activities. This is an area that lends itself to "hands on" activities and much use can be made of math lab techniques.

The children should by now be familiar with a Celsius thermometer. The temperature range between 0° and 100° is divided into 100 equal parts, called

degrees. Conversion to the Fahrenheit scale is not to be stressed, but examples may be given showing their relation. Example, in 25°F a man might be shoveling snow while in 25° Celsius he might be swimming. The human body temperature is 98.6°F but is 37° Celsius.

Some pupils might wish to try experiments such as finding the temperature of ice water and that of water from the hot water tap. Encourage them to find the average room temperature or the average outdoor temperature for a day or week.

In metric measurement, liquid and dry measure are the same. If 25 liters of grain have a mass of 20 kilograms, what is the mass of 1 liter of grain in kilograms?

The youngsters should also have experience with graduated cylinders which are marked in liters or milliliters.

Introduce the concept of area and develop area measurement intuitively. Limit the work to square centimeters, square decimeters, and square meters. Centimeter graph paper is useful for area study. One activity might be to have the child outline his hand or some other object on the graph paper and estimate the area.

Fifth graders can extend their knowledge of measurement by working with distance in our solar system. Develop a table and use it to demonstrate the planetary distances to the sun and some of the planets. A similar table may be created to show the diameters of the planets.

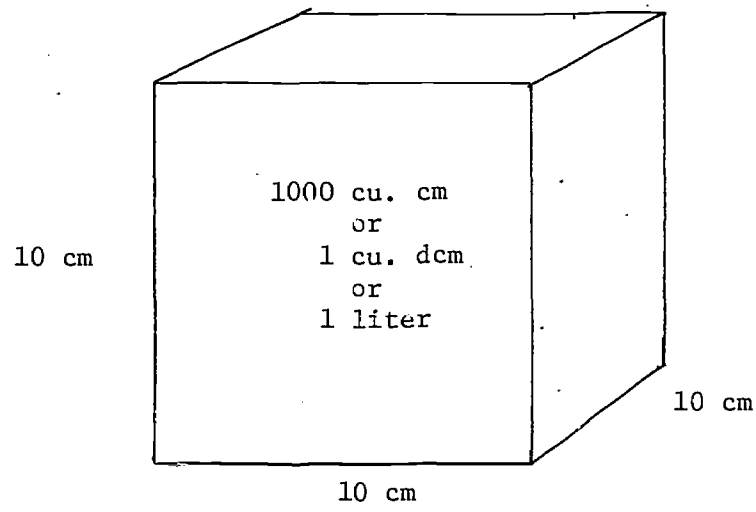
	Distance from Sun	
	Kilometers	Miles
Sun	...	...
Mercury	58 million	36 million
Venus	108 "	67 "
Earth	149 "	93 "
Mars	228 "	142 "
Jupiter	778 "	483 "
Saturn	1430 "	886 "
Uranus	2870 "	1783 "
Neptune	4490 "	2793 "
Pluto	5900 "	3666 "

GRADE 6

Continue metric measure activities to extend understanding and use of metric units.

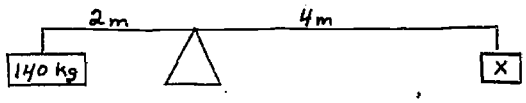
Develop the idea of volume of rectangular solids using objects and pictorializations.

Stress the fact that a liter is one cubic decimeter or 1000 cu. cm (cc or sometimes cm^3).



Word problems using volume should be presented at this grade level. Provide practice in adding, subtracting, multiplying and dividing with numbers that are metric measures.

Science education can be integrated with mathematics education very well at this level. Information about pulleys, levers, and inclined planes may be taught as a springboard for future science concepts. Use metric measurements.



If the lever balances, what is the mass of x? Physical experiments with scientific apparatus will create interest and, if calculations are kept simple, the formulas will be shown to work.

Angle measures are the same in the metric system as they are in the English system. There are 360 degrees in a circle. Pupils should be able to recognize and measure acute, obtuse, and right angles.

METRIC-ENGLISH CONVERSIONS?

The prevailing opinion among educators is that conversions from the metric system to the English measurement system and from the English to the metric should be a very small part of metric instruction. Many educators feel that conversion between the two systems should not be included at all. They feel that it is much better for the student to do his measurement thinking within one system. There is really little necessity for conversion between the systems.

If some conversion is desired, either to show relationships between units or for practice with multiplication and division, then conversion factors should be given to the pupils. They should not be required to memorize conversion factors. Estimates should be encouraged before computations.

The following relationships may be used:

1 cm = .39 in. (approximately)	1 in. = 25.4 mm
1 m = 3.28 ft. (approximately)	1 in. = 2.54 cm
1 m = 1.09 yd. (approximately)	1 ft. = 0.30 m (approximately)
1 km = 0.62 mi. (approximately)	1 yd. = 0.91 km (approximately)
1 kg = 2.2 lbs. (approximately)	1 mi. = 1.6 km (approximately)
	1 lb. = 0.45 km (approximately)

WHAT'S BEING DONE

The National Council of Teachers of Mathematics encourages and supports the implementation for the metric system. The feeling is that the metric system should be taught beginning in the 1973-74 school year by teachers of all grades.

The United States Office of Education has funded a Center for Metric Education located at Western Michigan University, Kalamazoo, Michigan, 49001. Its first year of operation is devoted to recommending changes in teacher education programs and to developing associated materials.

A number of states, including California and Minnesota, have started to formalize metric measurement education.

BIBLIOGRAPHY

Committee on the Metric System. The Metric System of Weights and Measures. National Council of Teachers of Mathematics - 20th Yearbook. Bureau of Publications, Teachers College, Columbia University, New York, 1948, 303 pp.

DeSimone, Daniel V. A Metric America: A Decision Whose Time Has Come. U.S. Metric Study, Washington, D.C.: Superintendent of Documents, U.S. Government Printing Office (Sip 20402), 1970, 192 pp., Bulletin No. CI 3.10:345. Cost $2.25.

Joly, Roxee W. "Changing to the Metric System - An Idea Whose Time Has Come." National Association of Secondary School Principals Bulletin. November 1972. Vol. 56, No. 367, pp. 47-59.

Kendig, Frank. "Coming of the Metric System." Saturday Review. December 1972. Vol. LV, No. 48, pp. 40-44.

National Council of Teachers of Mathematics. The Arithmetic Teacher. April 1973. Vol. 20, No. 4 and May 1973. Vol. 20, No. 5. (Both issues have a number of articles on metrication.)

Robinson, B. "Education." National Bureau of Standards (U.S.) Special Publication, pp. 345-6, (1971).

U.S. Department of Commerce. National Bureau of Standards. "The English and Metric Systems of Measurement." Special Publication 304A. (Revised 1970.)

All You Will Need to Know About Metric

(For Your Everyday Life)

10

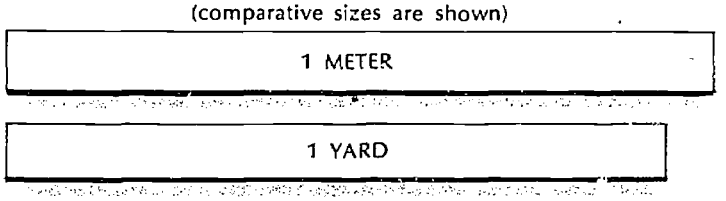
Metric is based on Decimal system

The metric system is simple to learn. For use in your everyday life you will need to know only ten units. You will also need to get used to a few new temperatures. Of course, there are other units which most persons will not need to learn. There are even some metric units with which you are already familiar: those for time and electricity are the same as you use now.

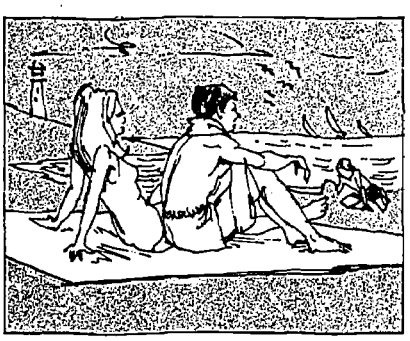
BASIC UNITS

METER: a little longer than a yard (about 1.1 yards)
LITER: a little larger than a quart (about 1.06 quarts)
GRAM: about the weight of a paper clip

(comparative sizes are shown)



25 DEGREES FAHRENHEIT

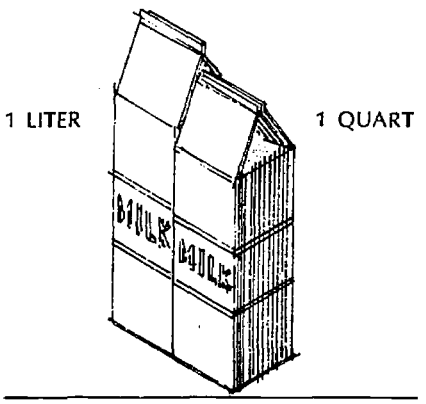


25 DEGREES CELSIUS

COMMON PREFIXES
(to be used with basic units)

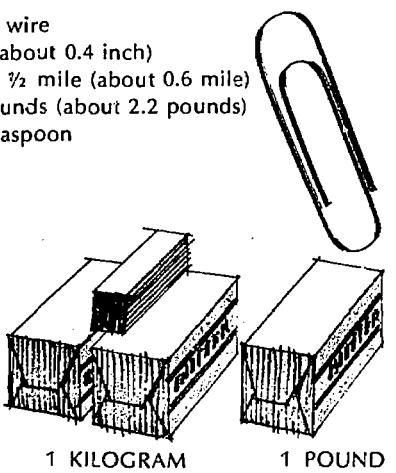
Milli: one-thousandth (0.001)
Centi: one-hundredth (0.01)
Kilo: one-thousand times (1000)

For example:
1000 millimeters = 1 meter
100 centimeters = 1 meter
1000 meters = 1 kilometer



OTHER COMMONLY USED UNITS

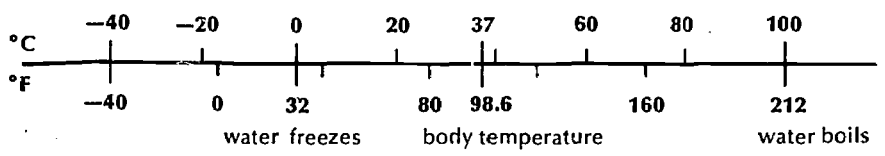
Millimeter:	0.001 meter	diameter of paper clip wire
Centimeter:	0.01 meter	width of a paper clip (about 0.4 inch)
Kilometer:	1000 meters	somewhat further than ½ mile (about 0.6 mile)
Kilogram:	1000 grams	a little more than 2 pounds (about 2.2 pounds)
Milliliter:	0.001 liter	five of them make a teaspoon



OTHER USEFUL UNITS

Hectare: about 2½ acres
Tonne: about one ton

TEMPERATURE
degrees Celsius are used



For more information, write to: Metric Information Office, National Bureau of Standards
Washington, D.C. 20234